DATA REPORT: MAGNETIC ANISOTROPY OF SAMPLES IN A FAULT ZONE AT ODP SITE 1117 IN THE WESTERN WOODLARK BASIN (PAPUA NEW GUINEA)

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ABSTRACT

At Site 1117, drilled during Leg 180 of the Ocean Drilling Program in the Woodlark Basin, we cored a fault zone and recovered fault gouge, mylonitized and brecciated gabbros, and undeformed gabbro. We measured the anisotropy of magnetic susceptibility for the rock samples. The susceptibilities of the fault gouge samples were lower than those of the undeformed gabbro, and those of deformed gabbros were lowest. The anisotropy degrees of the fault gouge samples were higher than those of the deformed and undeformed gabbros. Oblate magnetic fabrics were dominant in the samples from the fault zone.

INTRODUCTION

One of the primary objectives of Ocean Drilling Program Leg 180 was to characterize the composition and in situ properties of an active low-angle normal fault zone to understand how such faults slip. Site 1117 is on the upper slope of the northern flank of Moresby Seamount where the fault surface of a low-angle normal fault cropped out. Rotary core barrel (RCB) coring was used at three holes. RCB cores indicated that the minimum thickness of a shear zone was ~100 m on the footwall (Shipboard Scientific Party, 1999). We measured the magnetic anisotropy and rock magnetic properties on samples collected from the shear zone. Magnetic fabrics and rock magnetic parameters have been shown
to provide useful information that reveal deformation features in fault zones (e.g., MacDonald and Ellwood, 1987; Tarling and Hrouda, 1993). In this chapter, we report data on the anisotropy of magnetic susceptibility (AMS) obtained from the samples described above.

**SAMPLES AND METHOD**

Among the three holes at Site 1117, Hole 1117A (9°46.526′S, 151°32.945′E) was cored to 111.1 meters below seafloor. Noncumulate quartz magnetite gabbros were recovered at the base. Brecciated and then mylonitized equivalents in the cores above the base showed an upward-increasing shearing and alteration, and in the surficial core ~4 m of fault gouge was recovered. Shipboard analysis defined the following four structural domains (Shipboard Scientific Party, 1999):

- Domain I, fault gouge, in Cores 180-1117A-1R and 2R;
- Domain II, mylonite zone, in Cores 180-1117A-2R to 7R;
- Domain III, brecciated zone, in Cores 180-1117A-8R to 12R; and
- Domain IV, undeformed zone, in Cores 180-1117A-13R and 14R.

Soft clayey material comprised the fault gouge of Domain I and consisted of a mixture of talc, chlorite, ankerite, and serpentine. These minerals were alteration products of the gabbro found at the base. The initial structure in the fault gouge was difficult to assess because of coring-related deformation. In Domain II, epidote-rich metamorphic rocks recovered were mylonites and cataclasites showing developed anastomosing foliation planes, shear bands, and fibrous quartz pressure shadows. Major minerals were epidote, quartz, chlorite, and calcite. Domain III was defined by the brecciation of gabbroic rocks. Metamorphism by hydrothermal alteration was inferred in the rocks. Domain IV consisted of an undeformed magnetite-quartz gabbro with noncumulate structure. Undeformed fresh gabbros were also recovered in Core 180-1117A-11R in Domain III.

We collected 13 cubic samples from Domain I using 8-cm$^3$ plastic cubes (2 cm × 2 cm × 2 cm). Five cubic samples were also cut out from rock pieces of deformed gabbros in Domains II and III (four) and an undeformed gabbro in Domain III (Sample 180-1117A-11R [Piece 7]). Among the 15 samples, the AMS of six samples was measured on board ship with a KLY-2 susceptibility meter (AGICO, Inc.); the remaining samples were measured after Leg 180 using a KLY-3S susceptibility meter (AGICO, Inc.) at Kyoto University. The corrected anisotropy degree ($P_j$) and shape parameter ($T$) of the susceptibility ellipsoid were calculated after Jelinek (1981). The AMS parameters obtained are reported in this chapter, including results from onboard measurements.

**RESULTS AND DISCUSSION**

AMS results are listed in Table T1 and plotted in Figures F1 and F2. Initial mean volume susceptibilities of samples showed a distinctive feature. Fault gouge samples of Domain I had susceptibilities of $10^{-3}$ to $10^{-2}$ SI. An undeformed gabbro sample, the protolith of the gouge, showed the highest value, whereas susceptibilities of deformed gabbro samples from Domains II and III were $<10^{-3}$ SI. The susceptibility values imply that the main carrier of AMS is a ferrimagnetic mineral for the gouge.
and undeformed gabbro samples, whereas the contribution of both ferri-
magnetic and paramagnetic minerals to the AMS may be inferred for
the deformed gabbros (Tarling and Hrouda, 1993). The acquisition
curves of isothermal remanent magnetization showed that the gouge
and deformed/undeformed gabbro samples were saturated at ~0.2 T
(Shipboard Scientific Party, 1999), which implies the presence of mag-
netite and/or maghemite. Petrological observations on board ship indi-
cated the existence of magnetite in undeformed gabbro (Shipboard
Scientific Party, 1999). Magnetite may be considered a principal AMS
carrier in the undeformed gabbro. The gouge samples in Domain I con-
sisted of hydrothermal alteration products and deformed gabbros in
Domain II and III that were subjected to hydrothermal alteration (Ship-
board Scientific Party, 1999). The existence of maghemite might have
been inferred in the gouge and deformed gabbro samples as one of ferri-
magnetic minerals that contribute to the AMS. Further rock magnetic
analysis will be needed to identify AMS carriers.

The \( P_j \) values of the fault gouge samples were >1.1, and those of the
deformed and undeformed gabbros were <1.1 (Fig. F1). All samples but
one showed positive \( T \) values, that is, the fabrics had an oblate shape.
The oblateness of the magnetic fabric appeared to increase as the \( P_j \)
value increased. Shallow inclinations of K3 axes (<30°) were dominant,
indicating that magnetic foliation planes were close to vertical (Fig. F2).
Because drilling-related deformation was observed in the fault gouge
cores (Shipboard Scientific Party, 1999), these AMS features might be attri-
buted to a coring effect.

Gabbro samples showed low \( P_j \) values (<1.1), especially the brecciated
gabbros of Domain III (Core 180-1117A-9R) had the lowest values (Fig.
F1). The \( T \) values for the deformed gabbros ranged between ~0.22 and
0.44 and were lower than those for the undeformed gabbro (Sample
180-1117A-11R-1, piece 7). K3 axes of the deformed gabbros had moder-
ate inclinations, whereas the undeformed gabbro sample yielded a subhorizontal magnetic foliation with steep inclination of the K3 axis
(Fig. F2). Structural analysis on the deformed and undeformed gabbro
samples will be necessary to clarify the relationship between the mag-
netic fabrics and deformation features of the rocks.

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REFERENCES


Figure F1. Plots of AMS parameters.

Sample 180-1117A-\(\cdot\) Mean volume susceptibility (\(K_m\))

- 1R-1, 20-22 cm
- 1R-1, 29-31 cm
- 1R-1, 121-123 cm
- 1R-1, 128-130 cm
- 1R-2, 24-26 cm
- 1R-2, 71-73 cm
- 1R-2, 103-105 cm
- 1R-2, 125-127 cm
- 1R-3, 10-12 cm
- 1R-3, 45-47 cm
- 1R-3, 61-63 cm
- 1R-3, 76-78 cm
- 2R-CC, 7-9 cm
- 7R-1 (Piece 1)
- 9R-1 (Piece 8)
- 9R-1 (Piece 17)
- 9R-1 (Piece 19)
- 11R-1 (Piece 7)

Corrected anisotropy degree (\(P_j\))

Shape parameter (\(T\))
Figure F2. Orientations of the principal susceptibility axes of magnetic fabrics. A. Inclination values of the principal axes. B. Equal-area projection of the axes. The directions of the maximum (K1), intermediate (K2), and minimum (K3) principal axes are plotted as squares, triangles and circles, respectively. Solid symbols are on the lower hemisphere.
Table T1. Results of AMS measurements, Site 1117.

<table>
<thead>
<tr>
<th>Core, section, interval (cm)</th>
<th>Volume (cm³)</th>
<th>Mean volume susceptibility, Km (SI)</th>
<th>Normalized susceptibility of principal axes</th>
<th>Degree of anisotropy (P)</th>
<th>Shape parameter (T)</th>
<th>Direction of principal axes ()</th>
<th>Direction of principal axes ()</th>
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<td></td>
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<td>Core, section,</td>
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<td>interval (cm)</td>
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<td>Km (SI)</td>
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<td>1R-2, 26–34</td>
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Note: * = measured on board.